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Irradiation of cytosine adsorbed in a clay mineral

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Abstract. Clay minerals might have played an essential role in the early Earth. Clays are known to have a high affinity for organic compounds. In this work, we studied the possible protector role of clays toward cytosine, a nitrogen base adsorbed into the clay and exposed to the high radiation field. The results show that cytosine can resist high radiation dose with the clay. In contrast, the survival toward the irradiation of this compound without the clay is meager.

Key words. Cytosine – nucleic acids radiolysis – chemical evolution

1. Introduction

Cytosine is a nitrogen base important in biological systems, such as genetic and energy processes. Cytosine is formed in prebiotic conditions. Its synthesis and stability in environmental conditions are of paramount importance in chemical evolution. There are synthesis of cytosine and other nitrogen bases simulating the primitive Earth (Deamer 2011). On the other hand, clay minerals are considered the most likely material to promote organic reactions at the interface of the hydrosphere and lithosphere. J. D. Bernal (Brack 2013) suggested that clays act as concentrators of biological precursor molecules. Clays may protect these molecules from high-energy radiation. Despite the importance of nucleic acid bases in a prebiotic environment, few papers deal with the survival of this type of compound. In particular, there are none about the study of the stability of cytosine and other bases like thymine and uracil in an aqueous medium, at high temperatures, or in the presence of high radiation fields. The attempt of this work is to show preliminary results about the studies of the stability of cytosine as prototype of a nucleic acid base in a high-energy radiation field and the presence of a clay mineral, to determine the protector role of clays when they have an adsorbed compound and the clay-organic system is exposed to radiation in an experiment simulated wet/dry cycles.

2. Experimental procedures

2.1. Preparation of solutions

Aqueous solutions of cytosine, from Sigma Chemical Co. (USA) in concentrations of

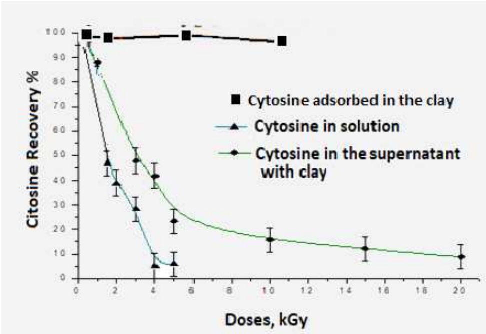

Fig. 1. Recovery of cytosine as a function of the dose in the different systems studied. Filled circles: cytosine in aqueous solution. Filled triangles: cytosine in a clay suspension.

$1x10^{-3}$ to $1x10^{-4}$ M, pH 2 were prepared in an oxygen-free glass container. The water and glassware were treated according to Draganić & Draganić (1971).

2.2. Adsorption/desorption experiments

A set of samples was prepared with clay mineral (Na-montmorillonite from Wyoming bentonite). The adsorption of the cytosine at pH 2 was done as it is described previously (Perezgasga et al. 1996). The solutions were irradiated at different doses, using a source of cobalt-60 (Gamma beam 651-PT). The doses used were measured according to Fricke (Draganić & Draganić 1971) from 1-20 kGy. The desorption was made at pH 9 with sodium hydroxide.

HPLC and UV spectroscopy were used to analyze cytosine that remains in the solution.

3. Results

Figure 1 shows the effect of the irradiation dose in the recovery of cytosine. The results obtained with the cytosine-clay, system, show that the base can resist high radiation dose with the clay (Fig. 1 filled circles).

In contrast, the survival toward the irradiation of this compound without the clay is low (Fig. 1 triangles). The role of clay as protector of the organic molecules was observed in these experiments. This protector role, after exposure to ionizing radiation, also was observed in the supernatant, when the amount of cytosine added to the clay exceed the limit of active sites saturating the clay (Fig. 1 circles) and remain in the solution (filled triangles). When the system is drying, simulating dry/wet circles, the recovery is higher.

4. Conclusions

These experiments simulated wet/dry conditions that may occur in a small lagoon and crater lakes in the primitive Earth. Cytosine (pyrimidine bases), can be recovered after the irradiation when it is adsorbed into clay and in the suspension when the active sites of the clay are saturated. In these series of experiments, the protection role of the clays, toward ionizing radiation was observed for cytosine.

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